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FINAL REPORT

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We have investigated a number of important issues regarding the generation of oblique magnetosonic waves, their steepening to form shocklets, and further evolution of shocklets into less coherent structures. The following provides a brief summary of these studies.

1. SUMMARY OF WORK PERFORMED

A. Generation of Oblique Magnetosonic Waves:

One of the outstanding issues regarding the excitation of magnetosonic waves has been the observational evidence that obliquely propagating waves are dominant at comets and planetary foreshocks despite the predictions of linear theory that maximum growth occurs at parallel propagation. To address this issue, we have conducted a detailed linear theory using a beam-ring distribution function. The results have shown that such distribution functions are associated with four separate instabilities. Two of these instabilities are similar to the right hand resonant ion/ion and the non-resonant instabilities which are also present in the case of a field aligned beam. The other two instabilities are associated with the presence of ring part of the distribution function. One of these instabilities excites magnetosonic waves with maximum growth in the oblique directions. The other excites Alfvén waves with maximum growth in the oblique directions. The importance of the former instability is that it may explain the oblique nature of the magnetosonic waves observed at planetary foreshocks and comets. In order to understand the nonlinear properties of these various instabilities, we have also conducted 2-D hybrid (particle ions, fluid electrons) simulations. We have found that when the beam density is sufficiently large so that the non-resonant instability has the largest growth rate, these waves dominate the initial wave power in the system. At later times, however, the obliquely propagating magnetosonic waves become dominant. Another important finding was that when the two instabilities which excite magnetosonic waves have the largest growth rates, the system is dominated by the obliquely propagating magnetosonic waves. This is despite the fact that the largest growth rate for one of the instabilities occurs in the parallel direction. The exact cause of this is not currently understood and is under investigation.

B. Formation and Evolution of Shocklets:

In order to understand the nature of the nonlinear processes leading to the steepening of shocklets, as well as, their further evolution into less coherent structures we have used two new techniques. One is the use of wavelet transform which as compared to Fourier transform is much more useful in studying of localized structures such as shocklets. The other is the use of neural networks which allow for a more rigorous description of shocklets. The wavelet transform analysis of the shocklets has unambiguously determined the spatial extent of the whistler wavepacket associated with shocklets. It has been found that these waves are generated at the steepened edge of the shocklets by the cross-field currents associated with the field gradient. We have also found that during the nonlinear steepening process forward propagating magnetosonic waves as well as backward propagating Alfvén and magnetosonic waves are generated. It is this process that eventually leads to the steepening and the formation of shocklets.

The other aspect of our study has been to use neural nets to identify shocklets embedded in an arbitrary magnetic field structure and also train a neural net to predict further evolution shocklets. The former task has both theoretical as well as practical applications. From a practical point of view, a trained neural net can identify shocklets in a large magnetic field data set on much shorter time scale as compared to visual inspection. From the theoretical point of view, we will be able to describe in a rigorous manner what a shocklet is and what aspects of it change with time. We have had considerable progress in this area and are quite optimistic about such capabilities in a very short time scale. As for the predictive capabilities of neural nets, they can be used to assess if the development of shocklets into less coherent structures is a random or a deterministic process. The answer to this question will determine the extent to which evolution of shocklets can be understood and predicted. The results obtained so far, suggest that achievement of such predictive capability may be a realistic task.

2. PAPERS AND PRESENTATIONS

Publications:

1. Karimabadi, H., N. Omidi, and S. P. Gary, "Ion scattering and acceleration by low frequency waves in the cometary environment," Proceedings of Yosemite '93, Conference on Solar System Plasma Physics, *Geophys. Monograph*, 1993.

2. Omidi, N., H. Karimabadi, D. Krauss-Varban, and K. Killen, "Generation and nonlinear evolution of oblique magnetosonic waves: Application to foreshock and comets," Proceedings of Yosemite '93, Conference on Solar System Plasma Physics, *Geophys. Monograph*, 1993.

Invited Talks:

1. Omidi, N., and H. Karimabadi, "Nonlinear Evolution of ULF Waves and Their Transition to Turbulence: Application to Waves in the Foreshock and Comets," Yosemite '93, Conference on Solar System Plasma Physics: Resolution of Processes in Space and Time, Yosemite National Park, California February 1993.

Contributed Talks:

1. Karimabadi, H., N. Omidi, and S. P. Gary, "Two-dimensional hybrid simulations of the cometary ion pickup process and comparison with theory," AGU Spring Meeting, Baltimore, Maryland, May 1993, EOS, 74, 248.

2. Omidi, N., H. Karimabadi, and D. Krauss-Varban, "Two-dimensional simulations of steepened magnetosonic waves," AGU Spring Meeting, Baltimore, Maryland, May 1993.